



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Random lasers using chiral nematic and smectic liquid crystals

Citation for published version:

Morris, SM, Gardiner, DJ, Qasim, MM, Hands, PJW, Wilkinson, TD & Coles, HJ 2012, 'Random lasers using chiral nematic and smectic liquid crystals', 24th International Liquid Crystal Conference (ILCC 2012), Mainz, Germany, 19/08/12 - 24/08/12. <<http://www.ilcc2012.de/>>

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Random lasers using chiral nematic and smectic liquid crystals

S. M. Morris*, D. J. Gardiner, M. M. Qasim, P. J. W. Hands, T. D. Wilkinson, and H. J. Coles

Centre of Molecular Materials for Photonics and Electronics, Department of Engineering, University of Cambridge, United Kingdom

Random lasers, whereby the feedback occurs as a result of multiple scattering instead of a well-defined cavity, have been of interest in recent years as they exhibit a range of properties that are not readily achievable with conventional lasers [1]. In particular, the output from these lasers can occur in all directions and can be made to have a broad or narrow linewidth depending upon whether the modes are extended or localized. Liquid crystals are an excellent candidate for these lasers as they possess very strong scattering that can be controlled using external stimuli. In this presentation, results are presented on random laser emission in both the chiral nematic and smectic A phases demonstrating how the emission characteristics can vary when in the presence of electric fields [2 - 4]. It is found that, for multistable organosiloxane liquid crystals, the threshold for random lasing is lower when electro-hydrodynamic instabilities are present than for a static scattering state in the absence of an applied electric field, Figure 1 [3]. Results are also presented that show how the laser feedback mechanism can be controlled using chiral nematic liquid crystals that have a negative dielectric anisotropy. For low frequencies of a bipolar square wave, electrohydrodynamic instabilities result in random laser emission due to the multiple scattering of light whereas band-edge lasing is observed at high frequencies of the applied electric field where the helicoidal structure is stabilized through dielectric coupling [4].

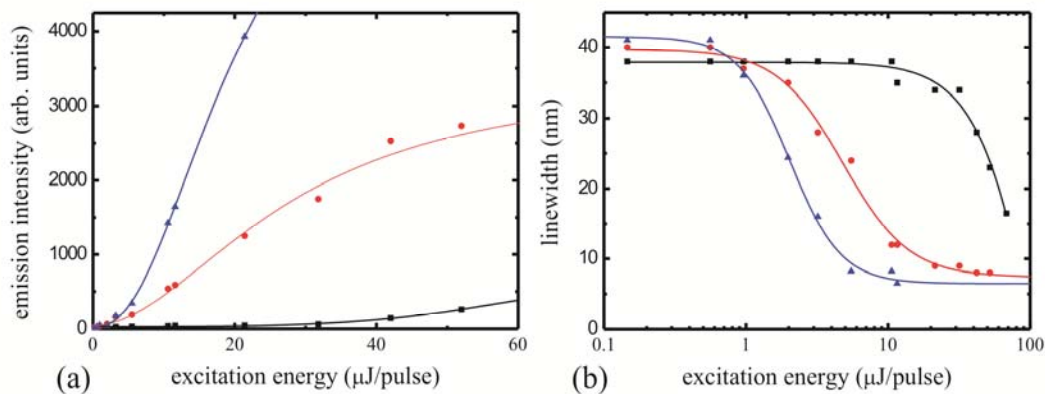


Figure 1. Emission characteristics of the dye-doped smectic A sample for the three different states: transparent (squares), static scattering (circles), and dynamic scattering (triangles) (a) the peak emission intensity as a function of excitation energy and (b) the full-width at half maximum (FWHM) as a function of excitation energy. The lines in (b) represent sigmoidal fits to the experimental data.

References:

- [1] D. S. Wiersma, *The Physics of Random Lasers*, Nat. Phys. **4**, 359 (2008).
- [2] S. M. Morris, A. D. Ford, and H. J. Coles, *Electronic control of Nonresonant Random Lasing from a Dye-doped Smectic A Dynamic Scattering Device*, Appl. Phys. Lett. **86**(14), 141103, (2005).
- [3] S. M. Morris, D. J. Gardiner, M. M. Qasim, P. J. W. Hands, T. D. Wilkinson, H. J. Coles, *Lowering the excitation threshold of a random laser using the dynamic scattering states of an organosiloxane smectic A liquid crystal*, J. Appl. Phys., **111** (3), 033106, (2012).
- [4] S.M. Morris, D.J. Gardiner, P.J.W. Hands, M.M. Qasim, T.D. Wilkinson, I.H. White, H.J. Coles, *Electrically switchable random to photonic band-edge laser emission in chiral nematic liquid crystals* Appl. Phys. Lett. **100**, 071110, (2012).

* presenting author; E-mail: smm56@cam.ac.uk